

DRY CABINETS FOR USE IN MOISTURE SENSITIVE DEVICE MANAGEMENT IN ELECTRONICS MANUFACTURING

FIELD OF THE INVENTION

5 The invention relates to improvements in the field of electronic packaging & assembly and the soldering of ICs or passive devices on printed circuit boards.

BACKGROUND OF THE INVENTION

10 The ongoing integration and miniaturization of components for electronic circuitry has become a growing challenge to the limits of printed wiring board technology over the last twenty years. Printed circuit boards or printed wiring boards (PWB) as they are more commonly termed, play several key roles. First, the electrical components, such as specially packaged integrated circuits, resistors, etc., are mounted or carried on the surface of the flat usually sturdy card-like board. Thus, the PWB serves as a support for
15 the components. Secondly, using chemically etched or plated conductor patterns on the surface of the board, the PWB forms the desired electrical interconnections between the components. In addition, the PWB can include a metal area serving as a heat sink.

20 Increased use of integrated circuits, and surface mount technology (SMT) has accelerated the densification of electronic circuitry. Surface mount devices (SMD) are applied directly to the surface of the PWB and soldered using vapor phase reflow (VPR), infra-red (IR) or other mass soldering techniques. SMT is revolutionizing the electronic manufacturing industry by reducing assembly cost by about 50%, increasing component density by over 40% and enhancing reliability.

25 In a conventional SMD package, a silicon die is mounted on a die pad of a multilayer organic substrate. The entire die pad area of the substrate is coated with an adhesive which bonds the silicon die to the substrate. Unfortunately, moisture inside a

plastic SMD package turns to steam and expands rapidly when the package is exposed to the high temperatures of VPR, IR soldering, or, if the package is submerged in molten solder, wave soldering. Under certain conditions, the pressure from the expanding moisture and steam can cause internal delamination of the plastic from the chip and/or substrate, internal cracks that do not extend to the outside of the package, band damage, wire necking, bond lifting, thin film cracking, or cratering beneath the bonds. In the most severe case, the stress can result in external package cracks. This is commonly referred to as the "popcorn" phenomenon because the internal stress causes the package to bulge and then crack with an audible "pop" sound. Surface mount devices (SMD) are more susceptible to this problem than through-hole parts because SMDs are exposed to higher temperatures during reflow soldering. The reason for this is that the soldering operation must occur on the same side of the circuit board as the surface mount device. For through-hole devices, the soldering operation occurs under the circuit board, which shields the through-hole devices from the hot solder. Also generally, SMDs have a smaller minimum plastic thickness from the chip or mount pad interface to the outside of the plastic package.

Fractures created in the adhesive material, or delamination at the adhesive-substrate interface are the most common causes of SMD package failure. Such a failure is very common in the "popcorn" test, which is a moisture sensitivity test. Conventional SMD packages can only pass the Institute for Interconnecting and Packaging Electronic Circuits (IPC) and the Joint Electronic Device Engineering Council (JEDEC) Level 3 Moisture Sensitivity Test. Some advanced packages can pass the Level 2 Moisture Sensitivity Test, but the Level 1 Moisture Sensitivity Test remains extremely challenging.

The IPC/JEDEC Moisture Sensitivity Test (the popcorn test) has 3 levels. Level 3 Moisture Sensitivity requires that the SMD package be subjected to 30° C at 60%

relative humidity for 192 hours, then cycled through three IR/convection heating cycles, which follow specific requirements. Level 2 Moisture Sensitivity requires that the package be subjected to 85° C at 60% relative humidity for 168 hours and then cycled through three IR/convection heating cycles. Level 1, which is the highest level of

5 moisture insensitivity, requires that the package be subjected to 85° C at 85% relative humidity for 168 hours, then subjected to three cycles of IR/convection heating (See JEDEC document No. JESD22-A112-A *Moisture-Induced Stress Sensitivity for Plastic Surface Mount Devices*).

Various techniques have been used to either limit the amount of humidity a SMD

10 package is subjected to between manufacturing of the package and the time of soldering to a printed circuit card. Techniques have also been used to help the SMD package to pass higher levels of the popcorn test.

To limit the amount of moisture an SMD package is subjected to prior to soldering to a printed circuit board, such packages are packed and shipped in hermetic

15 bags to prevent the absorption of moisture from the environment. For SMD packages that are not packed in hermetic bags or that have been subjected to the environment for sometime, it is an industry standard to bake dry the packages before surface mounting. The additional steps of either placing the SMD packages in hermetic bags, or baking them increases the manufacturing cost of a device or a product.

20 Plastic and non-hermetic surface mount devices can be seriously damaged from absorbed moisture overpressure when reflow soldered. To prevent this from happening, assemblers have adopted various preventive and reactive approaches. A common strategy involves storing the surface mount devices in dry cabinets that can maintain an atmosphere of less than 5% RH. However, to allow such low RH% in a

25 dynamic environment, one must do so by sweeping the dry cabinets with high flow rates of dry gas (typically N₂). As a result, operating such cabinets becomes expensive

in terms of operating costs. In many cases, the N₂ requirements prove to be a hurdle that prevents the establishment of the process in a manufacturing plant.

U.S. 6,560,839, assigned to Integrated Device Technology, Inc, also protects a moisture sensitive component from exposure to moisture above a predetermined
5 threshold level by placing the device into a container with a desiccant and then sealing the container. Once the moisture sensitive components are to be evaluated, the container is unsealed and the components removed from their container. After evaluation, the components are restored to the container, which is then resealed. The above steps are repeated until the components are placed into their container for either
10 shipment, or transportation outside the local testing environment. The protective container is any type of enclosure that minimizes the exposure of moisture-sensitive components to the ambient environment. Due to the effectiveness in stemming moisture accumulation, a baking step is not necessary immediately prior to shipment. Obviously, the repeated opening, testing, and reclosing of the container are added
15 steps which increase the manufacturing and handling costs of the device.

Equipment commercialized by Seika Instruments uses a self-desiccant material to dry the atmosphere of a dry cabinet. The Seika Instruments cabinets, however, do not maintain a RH% of less than 5% in a dynamic environment.

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SUMMARY OF THE INVENTION

The present invention is directed to a novel dry cabinet used to store SMDs at low humidity and prevent moisture-induced failures of the devices. In order to reduce the costs associated with prior art dry cabinets, the cabinet of this invention consists of building N₂ or dry gas storage cabinets that include an N₂ or dry gas generation system.
25 The self-contained N₂ or dry gas generation system eliminates the need for a centralized nitrogen or clean dry air system. This lowers the operational costs while

eliminating other installation costs associated with an N₂ infrastructure. The cabinet hence becomes independent by self-producing its dry gas needs. This is performed at minimal cost and eliminates other expensive installation costs for the N₂ infrastructure. The add-on compressed air dryer module or N₂ membrane generation system can be
5 installed on all types of dry storage cabinets, small or very large, including cabinets to store trays, bobbins, feeder carts, one-side assembled PWBs, or SMDs.

BRIEF DESCRIPTION OF THE DRAWINGS

The Figure is a front and side elevational view, partly cut away, of a dry cabinet
10 of this invention containing a self-generating dry gas source.

DETAILED DESCRIPTION OF THE INVENTION

The introduction of surface mount devices (SMDs) has significantly contributed to the advancement of electronic assembly. Plastic SMDs, especially, have
15 gained extreme popularity as such devices offer versatility and the inherent low cost of plastic packages. These devices, however, have the disadvantage of being sensitive to moisture. Moisture from atmospheric humidity diffuses through the permeable SMD package and if the moisture level inside the package reaches a critical point, the device may be damaged when brought up in the temperature during the reflow soldering
20 process. The rapid increase and high vapor pressure in the package combined with the thermal mismatch stress the component. Typical component failures include die cracking, internal corrosion, bond wire damage, and, in the worst case, external cracking. This is also referred to as the *popcorn effect* due to the audible popping at failure.

25 To avoid moisture-induced failures and popcorning, it is necessary to scrupulously comply with the floor life recommended by the manufacturer of the

component. The moisture sensitivity (MS) level to which the product has qualified (IPC/JEDEC J-STD-033A) indicates the floor life. In everyday practice, this is not always evident for practical reasons (tracking). By way of precaution, and when the floor life has expired, the J-STD-033A specifications recommend to 'bake' the components in order to remove the moisture they have gained from ambient humidity exposure. Baking as per the standard is normally done at an elevated temperature for a period varying from 24 hours (125° C) to 8 days (or more, 40° C). Baking normally concerns only components of level 3 to 6 due to their relatively short floor life.

While baking prevents moisture-induced failures and popcorning, other approaches exist that are more preventive in nature. The revision of IPC/JEDEC J-STD-033 in July, 2002 elaborates on alternative solutions. Typical solutions and strategies frequently involve the use of dry cabinets that can maintain an atmosphere less than 5% RH. However, few of the existing storage cabinets are able to reach and maintain that level in a production environment. The few cabinets that allow such low RH% do so by sweeping the dry cabinets with rather high flow rates of dry gas (typically N₂ from a cryogenic source but dry air or membrane N₂ could be used). As a result, operating such cabinets becomes expensive in terms of the operating costs associated with nitrogen usage. As dry cabinets gain adoption in PCB assembly environments, the need for cabinets that have lower operating costs is emerging. This is particularly critical in plants where nitrogen is not currently available. Installing a centralized nitrogen source can be expensive.

This invention reduces the costs associated with the adequate operation of a dry storage cabinet used for moisture sensitive device management in a PWB assembly environment. The cabinet unit of this invention has a self-generating dry gas source, which only requires some electric power and readily available compressed air. The cabinet unit produces dry gas at a very low marginal cost. Accordingly, the dry box or

cabinet can be located anywhere in a PWB assembly plant and does not require the need for a centralized N₂ system.

The dry cabinet of this invention includes a self contained dry gas generation system and is indicated in general, by reference numeral 10 in the Figure. The cabinet
5 10 typically will contain an access door 12 with handle 13 to open and close door 12 and allow ingress and egress into the interior of the cabinet 10. The access door 12 may include one or more windows or visualization sites 14 to allow the interior of the cabinet to be viewed from the outside. The cabinet 10 will typically contain a plurality of shelves 16 for storing the surface mount devices. Although a rectangular or box shape
10 cabinet is shown in the Figure, the particular shape of the cabinet does not form an important part of the present invention. Although not shown, cabinet 10 can include wheels at the bottom thereof to allow ease of movement of the cabinet around the SMT production facility.

Typically, to maintain a low humidity environment within the cabinet, the prior art
15 directed into the cabinet high flow rates of a dry gas, typically nitrogen, obtained from a centralized source of nitrogen such as a nitrogen supply or a cryogenic type generation system. In the dry cabinet of the present invention, there is provided an integrated dry gas generating system within the cabinet structure. The dry gas generating system receives a source of compressed air whether in the form of a modular source or a
20 centralized source to provide the desired dry gas within the cabinet. The use of a centralized or modular compressed air source and generating the desired dry gas at the cabinet greatly reduces the cost of providing the desired environment within the interior of the dry cabinet relative to the cost of providing the prior art centralized nitrogen or nitrogen-generating sources.

25 Again, referring to the Figure, compressed air from any available source, whether a modular supply of compressed air or centralized compressed air system,

enters the dry cabinet 10 via line 20. A valve 22 can direct the compressed air via line 20 to an air drying system 24 or nitrogen generating system 26, or both, contained within the structure of cabinet 10. The air dryer 24 and nitrogen generation system 26 are built within the base 18 of cabinet 10. The specific location of the dry gas forming system within the dry cabinet 10 is not critical to the invention.

Compressed air via line 20 is directed to either or both the air dryer 24 and nitrogen generator 26 via valve 22. If directed to the air dryer, the compressed air through valve 22 enters line 28 and then a filter 30 so as to remove air borne contaminants such as minute particulates and the like. From the filter 30, the compressed air stream enters the air dryer 24 via line 31. The air dryer 24 is a desiccator, which includes a mass of desiccant, which removes substantially all of the water vapor from the compressed air stream entering cabinet 10 via line 20. As previously stated, it is desired to maintain the environment within the interior of cabinet 10 to a relative humidity of less than 5 %.

Examples of desiccants which may be suitable are included in the list below which is not exhaustive: alumina, aluminum oxide, activated carbon, barium oxide, barium perchlorate, calcium bromide, calcium chloride, calcium hydride, calcium oxide, sulfate, glycerol, glycols, lithium aluminum hydride, lithium bromide, lithium chloride, lithium iodide, magnesium chloride, magnesium perchlorate, magnesium sulfate, molecular sieves, phosphorus pentoxide, potassium hydroxide (fused, sticks, etc.), potassium carbonate, resins, silica gel, sodium hydroxide, sodium iodide, sulfuric acid, titanium silicate, zeolites, zinc bromide, zinc chloride, and combinations of such desiccants. The desiccants may be used in various forms. For example, the desiccant may be a solid and/or a liquid. The desiccant may also comprise part of an aqueous solution.

From air dryer 24, the compressed air stream, now removed of substantially all of the water vapor initially contained therein is directed into the interior of the cabinet to sweep the cabinet and maintain an interior environment containing less than 5% relative humidity. Thus, from the air dryer 24, the dry air is sent via line 32 to a flow
5 controller 34 which can adjust for the volume of dry air directed into the interior of the cabinet via line 36. The flow controller should also include an on/off switch to initiate or stop gas flow if desired. From flow controller 34, and line 36, the dry air is directed to a series of dry gas injectors 38. The injectors 38 direct the dry gas, whether the dry air, or as will be explained below, nitrogen from nitrogen generator 26 into the interior of the
10 cabinet. The exact number and type of gas injectors directing the dry gas into the interior of cabinet 10 is not critical for this particular invention and one of ordinary skill in the art can determine the amount, size and type of dry gas injectors, which would be required for the individual cabinet interior space.

In the Figure, it is shown that the dry air from air dryer 24 can be directed to a
15 storage tank 40 prior to be directed into line 32 and ultimately into the interior of the cabinet. The storage tank 40 is optional and can be used to more accurately control the flow of dry gas into the interior of cabinet 10. Thus, at times, the environment within cabinet 10 may be such that no additional gas is required to be used to sweep the interior of the cabinet. At such times, the dry air or nitrogen can be stored in the optional
20 storage tank 40. Although one storage tank is shown, a separate storage tank for each of the air desiccator 24 or nitrogen generator 26 can be used. Further, a single storage tank with separate and sealed compartments for the dry air and nitrogen, respectively can also be utilized.

Instead of removing the water vapor from the compressed air stream, the dry
25 gas, which is injected into the interior of the cabinet, can be nitrogen formed by a nitrogen generator contained within cabinet 10. Thus, prior to this invention, nitrogen

has been used to sweep dry cabinets to maintain an environment of low relative humidity for the storage of SMDs in the cabinets for eventual shipment. However, such cabinets were linked to a centralized nitrogen-generating source, which can be very costly to construct and maintain. Accordingly, in this invention, a modular nitrogen generator is incorporated into the dry cabinet 10 of this invention. The nitrogen generator is shown as reference numeral 26 and generally comprises one or more membrane modules, used for separating nitrogen from the compressed air stream 20 and for producing a concentrated dry nitrogen gas stream. For example, one or more membranes, such as polyimide, polycarbonate, nylon, 6, 6, polystyrene, or cellulose acetate membranes may be used. In this invention, compressed air via line 20 is directed at least in part by valve 22 to line 42 and then through filter 44 to remove particulates from the compressed air stream. From filter 44 and line 46, the filtered compressed air stream is directed to nitrogen generator 26, shown as membrane modules 27 and 29, where the air is treated to separate oxygen from nitrogen in the air stream and produce a highly concentrated N₂ stream.

The permeable membranes that can be employed in the practice of the invention will commonly be employed in membrane assemblies typically positioned within enclosures to form a membrane module comprising the principal element of a membrane system. As understood with reference to the invention, a membrane system comprises a membrane module or a number of such modules, arranged for either parallel (as shown) or series operation. The membrane modules can be constructed in convenient hollow fiber form, or in spiral wound, pleated flat sheet membrane assemblies, or in any other desired configuration. Membrane modules are constructed to have a feed air surface side and an opposite permeate gas exit side. For hollow fiber membranes, the feed air can be added either to the lumen side or to the outer surface side of the hollow fibers.

It will also be appreciated that the membrane material employed for the air separation membrane can be any suitable material capable of selectively permeating a more readily permeable component of the feed gas, i.e. air. Cellulose derivatives, such as cellulose acetate, cellulose acetate butyrate and the like; polyamides and
5 polyimides, including aryl polyamides and aryl polyimides; polysulfones; polystyrenes and the like, are representative of such materials.

As indicated above, the permeable membranes comprising the membrane system positioned within cabinet 10 of the invention may be in any desirable form, with hollow fiber membranes being generally preferred. It will be appreciated that the
10 membrane material employed in any particular gas separation application can be any suitable material capable of selectively permeating a more readily permeable component of a gas or fluid mixture containing a less readily permeable component. The polymers discussed immediately above are representative examples of such materials. It will be understood in the art that numerous other permeable membrane
15 materials are known in the art and suitable for use in an air separation. As noted, the membranes, as employed in the practice of the invention, may be in any such form that is useful and effective for the air separation being carried out using the system and process of the invention.

One is a so-called "composite membrane" in which the active layer is positioned
20 coextensively adjacent to a structurally supportive and usually porous substrate. In a composite membrane the active layer and the substrate are not partial elements of a single, monolithic layer. They usually are produced by laying up one layer on another, such as by laminating two separate layers. The substrate can be a selectively gas permeable material but typically is not. As mentioned, due to porosity the substrate has
25 negligible gas separation properties and presents little resistance to transmembrane flux. The substrate primarily provides structural integrity for the active layer which is by

itself normally too thin to form a self supporting film or to withstand the pressure gradient across the membrane imposed during routine operation.

A preferred type of membrane is known as an asymmetric membrane. This membrane is characterized by an anisotropic structure in cross section normal to direction of permeate flow. Typically an asymmetric membrane has an active layer constituted by a continuous, dense thin skin at one surface and a porous, usually thicker support layer coextensively adjacent to the skin and tending to be increasingly porous with distance from the skin. The active layer and support layer of the asymmetric membrane are usually composed of the same selectively gas permeable substance. The skin is usually less than 1/10th of the thickness of the asymmetric membrane. Typically, the thickness of the skin is about 50-3000 Å, preferably about 50-1500 Å and more preferably about 50-1000 Å. The asymmetric membrane can be either monolithic or composite. That is, in a monolithic asymmetric membrane the active layer and support layer are parts of an integrated monolithic structure. In a composite asymmetric membrane, the asymmetric membrane includes a substrate adjacent to the asymmetric membrane layer. For example, a typical hollow fiber composite membrane can be formed by an annular core of a porous substrate surrounded by a coaxial annular sheath of the asymmetric membrane. In a composite asymmetric membrane the non-active layer of the asymmetric membrane and the substrate layer are sometimes collectively referred to as the "support layer". The asymmetric membrane layer and the substrate typically have different compositions.

Materials used for gas separation membranes are frequently polymeric. A diverse variety of polymers can be used for the supportive substrate of a composite membrane. Representative substrate polymers include polysulfones, polyether sulfones, polyamides, polyimides, polyetherimides, polyesters, polycarbonates, copolycarbonate esters, polyethers, polyetherketones, polyvinylidene fluoride,

polybenzimidazoles, polybenzoxazoles, cellulosic derivatives, polyazoaromatics, poly(2,6-dimethylphenylene oxide), polyarylene oxide, polyureas, polyurethanes, polyhydrazides, polyazomethines, cellulose acetates, cellulose nitrates, ethyl cellulose, brominated poly(xylylene oxide), sulfonated poly(xylylene oxide), polyquinoxaline, polyamideimides, polyamide esters, blends thereof, copolymers thereof, substituted materials thereof and the like. This should not be considered limiting since any material which can be fabricated into an anisotropic substrate membrane may find utility as the substrate layer of the present invention. Preferred materials for the substrate layer include polysulfone, polyethersulfone, polyetherimide, polyimide, polyamide compositions and copolymers and blends thereof.

A wide range of polymeric materials have desirable selectively gas permeating properties and can be used in the active layer. Representative materials include polyamides, polyimides, polyesters, polycarbonates, copolycarbonate esters, polyethers, polyetherketones, polyetherimides, polyethersulfones, polysulfones, polyvinylidene fluoride, polybenzimidazoles, polybenzoxazoles, polyacrylonitrile, cellulosic derivatives, polyazoaromatics, poly(2,6-dimethylphenylene oxide), polyphenylene oxide, polyureas, polyurethanes, polyhydrazides, polyazomethines, polyacetals, cellulose acetates, cellulose nitrates, ethyl cellulose, styrene-acrylonitrile copolymers, brominated poly(xylylene oxide), sulfonated poly(xylylene oxide), tetrahalogen-substituted polycarbonates, tetrahalogen-substituted polyesters, tetrahalogen-substituted polycarbonate esters, polyquinoxaline, polyamideimides, polyamide esters, blends thereof, copolymers thereof, substituted materials thereof, and the like. In addition, suitable gas separating layer membrane materials may include those found useful as the dense separating layer of composite gas separation membranes. These materials include polysiloxanes, polyacetylenes, polyphosphazenes, polyethylenes, poly(4-methylpentene), poly(trimethylsilylpropyne),

poly(trialkylsilylacetylenes), polyureas, polyurethanes, blends thereof, copolymers thereof, substituted materials thereof, and the like. Preferred materials for the dense gas separating layer include aromatic polyamide, aromatic polyimide compositions, polysulfone, polyether sulfone and blends thereof.

5 Hollow fiber membranes with dense regions are preferred for gas separation. Asymmetric hollow fiber membranes may have the discriminating region either on the outside of the hollow fiber, at the inside (lumen surface) of the hollow fiber, or located somewhere internal to both outside and inside hollow fiber membrane surfaces. In the embodiment wherein the discriminating region of the hollow fiber membrane is internal
10 to both hollow fiber membrane surfaces, the inside (lumen) surface and the outside surface of the hollow fiber membrane are porous, yet the membrane demonstrates the ability to separate gases. In the embodiment wherein gases are separated, the preferred polymeric materials for membranes include polyesterarbonates, polysulfones, polyethersulfones, polyimides, and polycarbonates. More preferred
15 polymeric materials for gas separation membranes include polycarbonates and polyesterarbonates. Preferred polycarbonate and polyesterarbonate membranes for gas separation include those described in U.S. Pat. Nos. 4,874,401; 4,851,014; 4,840,646 and 4,818,254; the relevant portions of each patent incorporated herein by reference for all legal purposes which may be served thereby. In one preferred
20 embodiment, such membranes are prepared by the process described in U.S. Pat. No. 4,772,392, the relevant portions incorporated herein by reference for all legal purposes, which may be served thereby. Particularly useful membranes for the air separation and generation of a concentrated dry N₂ gas stream are hollow fiber polymeric membranes produced by the present assignee, Air Liquide, under the tradename MEDAL.

25 The concentrated nitrogen gas stream is separated from the compressed air and is substantially dry as the water vapor is also separated from the nitrogen component

stream by the membrane. The dry nitrogen gas stream leaving generator 26 via line 48 can be optionally stored in storage tank 40 prior to being directed via line 32, flow controller 34 and line 36 to the dry gas injectors 38. Again, a separate tank 40 can be used to store the N₂ gas stream from the nitrogen generator 26 relative to storage of dry air from the air dryer 24. Nitrogen generating systems with bulk storage and flow control are known in the art and are particularly described in U.S. Pat. Nos. 5,266,101; 5,284,506; 5,302,189; 5,363,656; 5,439,507; and 5,496,388, the entire contents of which are herein incorporated by reference.

While the nitrogen generating system 26 has been described as comprising one or more membrane structures, or membrane modules, it is also possible to form a concentrated nitrogen gas stream from compressed air utilizing a particulate adsorbents in known pressure swing adsorption (PSA) systems. Thus, particulate adsorbents such as activated carbon, silica gels, and molecular sieves, such as zeolite and titania silicates, i.e. CTS-1, are known for separation of air into its individual components including formation of a concentrated nitrogen gas stream. Accordingly, the nitrogen generating system 26, which is incorporated into cabinet 10, can include one of more beds of adsorbent which under selective pressure conditions can adsorb oxygen or nitrogen and produce a concentrated dry nitrogen gas stream. Operation of PSA systems are known in the art in which cycles of pressurization (adsorption), depressurization (regeneration), and equalization of pressure are used to adsorb a gaseous component from a mixture and regenerate the adsorbed component from the adsorbent bed. U.S. Pat. No. 4,933,314 describes a particular molecular sieve carbon used for separating nitrogen or oxygen from air. U.S. Pat. No. 5,288,888 directed to producing a nitrogen enriched product by passing air through a bed of crushed zeolite and U.S. Pat. No. 6,068,682 which discloses crystalline titanium molecular sieves, CTS-1 are examples of known adsorbents which can be used to form a concentrated

nitrogen stream from air. Each of these listed U.S. patents are herein incorporated by reference in their entirety.

Similar to the membrane separation system, a concentrated nitrogen gas stream leaving a PAS module can optionally be stored in storage tank 40 and then directed to the dry gas injectors 38 via line 32, flow controller 34 and line 36.

It will be understood that while the dry cabinet 10 is particularly useful for storing surface mount devices during or after assembly, the dry cabinet of this invention has further use in preventing any type of device from being adversely affected by humid air during storage or transport before being utilized. In particular, any type of semiconductor, electronic, optical or magnetic component and the like can be stored in cabinet 10. The environment is free from water vapor, which can permeate any packaging or any pores in the device structure and cause permanent damage while in storage or during installation and use.

The dry gas, having swept the interior of cabinet 10 to maintain a very low relative humidity within the interior of the cabinet is released from the cabinet via line 50. Again, the control of the compressed air through line 20, valve 22 or any optional storage tank 40 and flow control 34 can maintain the desired pressure and low humidity conditions within the interior of cabinet 10. Thus, a gas leaving the interior of cabinet 10 via line 50 can be on a continuous or even intermittent basis.

While there has been described and illustrated several preferred embodiments of the present invention it will be apparent to those skilled in the art that variations and modifications are possible without the deviating from the broad scope of the present invention which shall be limited solely by the scope of the claims appended here too.